

1 WE CLAIM:

2 1. An apparatus for detecting leaks in a liquid storage  
3 tank comprising:

4 differential pressure sensor means having a low  
5 pressure measurement component and a high pressure  
6 measurement component;

7 protective enclosure means for protecting said  
8 differential pressure sensor means from materials  
9 and conditions when immersed in liquid contents of  
10 said storage tank;

11 said high pressure measurement component being  
12 configured for measuring tank bottom pressure  
13 within a liquid in which said cannister is  
14 immersed;

15 said low pressure measurement component being  
16 configured for receiving data indicative of  
17 atmospheric pressure substantially at the surface  
18 of said liquid

19 barometric pressure measuring means configured for  
20 measuring atmospheric pressure substantially at  
21 the surface of said liquid when said protective  
22 enclosure means is immersed therein;

1 barometric pressure and differential pressure  
2 calculation means configured for receiving first  
3 and second data reflecting, respectively, said  
4 tank bottom pressure and of said barometric  
5 pressure substantially at said surface of said  
6 liquid, and for adjusting said first data to  
7 substantially eliminate variations upon said  
8 measurements of said tank bottom pressure caused  
9 solely from atmospheric pressure variations to  
10 yield an atmospheric pressure adjusted tank bottom  
11 pressure;  
12 ambient temperature measurement means for measuring  
13 ambient temperature near said storage tank;  
14 tank dynamic and barometric pressure adjusted tank  
15 bottom pressure calculation means configured for  
16 receiving third data indicative of said  
17 atmospheric pressure adjusted tank bottom  
18 pressure, for receiving fourth data indicative of  
19 ambient temperature measurements by said ambient  
20 temperature measurement means, for receiving fifth  
21 data indicative of expansion characteristics of  
22 said storage tank, and for adjusting said third  
23 data with reference to said fourth and fifth data

1 to substantially eliminate variations upon  
2 measurements and calculations of said barometric  
3 pressure adjusted tank bottom pressure, caused  
4 solely by dimensional changes in said storage tank  
5 resulting from atmospheric temperature variations,  
6 to yield a tank dynamic adjusted tank bottom  
7 pressure;

8 tank content mass calculation means for calculating  
9 mass contents of said storage tank substantially  
10 based on said tank dynamic adjusted tank bottom  
11 pressure and user input data reflecting physical  
12 characteristics of said contents of said storage  
13 tank.

14  
15 2. The apparatus of Claim 1 wherein said protective  
16 enclosure means is configured for maintaining at least some  
17 components of said apparatus within said canister, including  
18 said differential pressure sensor, but excepting said low  
19 pressure measurement component and said high pressure  
20 measurement component, in a substantial vacuum.

21  
22 3. The apparatus of Claim 1 further comprising protective  
23 enclosure temperature management means configured for

1 maintaining the temperature of said protective enclosure  
2 substantially at a user-specified temperature.

3  
4 4. The apparatus of Claim 2 further comprising protective  
5 enclosure temperature management means configured for  
6 maintaining the temperature of said protective enclosure  
7 substantially at a user-specified temperature.

1           5. An apparatus for detecting leaks in a liquid storage  
2 tank comprising:  
3           differential pressure sensor means having a low  
4           pressure measurement component and a high pressure  
5           measurement component;  
6           protective enclosure means for protecting said  
7           differential pressure sensor means from materials  
8           and conditions when immersed in liquid contents of  
9           said storage tank;  
10          said high pressure measurement component being  
11          configured for measuring tank bottom pressure  
12          within a liquid in which said cannister is  
13          immersed;  
14          said low pressure measurement component being  
15          configured for receiving data indicative of  
16          atmospheric pressure substantially at the surface  
17          of said liquid  
18          first barometric pressure measuring means configured  
19          for measuring atmospheric pressure substantially  
20          at the surface of said liquid when said protective  
21          enclosure means is immersed therein and for  
22          communicating such measurement to said low side

measurement component of said differential  
pressure sensor;

second barometric pressure measuring means configured  
for measuring atmospheric pressure substantially  
at the surface of said liquid when said protective  
enclosure means is immersed therein;

barometric pressure and differential pressure  
calculation means configured for receiving first  
and second data reflecting, respectively, said  
tank bottom pressure and of said barometric  
pressure as measured by said first barometric  
pressure measuring means and for calculating  
pressure attributable to liquid content of said  
storage tank, and receiving third data from said  
second barometric measuring means and, based  
thereon, adjusting said pressure attributable to  
said contents of said storage tank to  
substantially eliminate variations upon said  
measurements thereof caused solely from  
atmospheric pressure variations to yield an  
atmospheric pressure adjusted tank bottom  
pressure;

1 ambient temperature measurement means for measuring  
2 ambient temperature near said storage tank;  
3 tank dynamic and barometric pressure adjusted tank  
4 bottom pressure calculation means configured for  
5 receiving fourth data indicative of said  
6 atmospheric pressure adjusted tank bottom  
7 pressure, for receiving fifth data indicative of  
8 ambient temperature measurements by said ambient  
9 temperature measurement means, for receiving sixth  
10 data indicative of expansion characteristics of  
11 said storage tank, and for adjusting said fourth  
12 data with reference to said fifth and sixth data  
13 to substantially eliminate variations upon  
14 measurements and calculations of said barometric  
15 pressure adjusted tank bottom pressure, caused  
16 solely by dimensional changes in said storage tank  
17 resulting from atmospheric temperature variations,  
18 to yield a tank dynamic adjusted tank bottom  
19 pressure;  
20 tank content mass calculation means for calculating  
21 mass contents of said storage tank substantially  
22 based on said tank dynamic adjusted tank bottom  
23 pressure and user input data reflecting physical

characteristics of said contents of said storage tank.

6. The apparatus of Claim 5 wherein said protective enclosure means is configured for maintaining at least some components of said apparatus within said canister, including said differential pressure sensor, but excepting said low pressure measurement component and said high pressure measurement component, in a substantial vacuum.

7. The apparatus of Claim 5 further comprising protective enclosure temperature management means configured for maintaining the temperature of said protective enclosure substantially at a user-specified temperature.

8. The apparatus of Claim 6 further comprising protective enclosure temperature management means configured for maintaining the temperature of said protective enclosure substantially at a user-specified temperature.



1           9. A method for detecting leaks in a storage  
2 receptacle; comprising the steps of:  
3           selecting a mass detection system comprising:  
4               differential pressure sensor means having a low  
5               pressure measurement component and a high  
6               pressure measurement component;  
7           protective enclosure means for protecting said  
8               differential pressure sensor means from  
9               materials and conditions when immersed in  
10           liquid contents of said storage tank;  
11           said high pressure measurement component being  
12           configured for measuring tank bottom pressure  
13           within a liquid in which said cannister is  
14           immersed;  
15           said low pressure measurement component being  
16           configured for receiving data indicative of  
17           atmospheric pressure substantially at the  
18           surface of said liquid  
19           barometric pressure measuring means configured for  
20           measuring atmospheric pressure substantially  
21           at the surface of said liquid when said  
22           protective enclosure means is immersed  
23           therein;

1 barometric pressure and differential pressure  
2 calculation means configured for receiving  
3 first and second data reflecting,  
4 respectively, said tank bottom pressure and  
5 of said barometric pressure substantially at  
6 said surface of said liquid, and for  
7 adjusting said first data to substantially  
8 eliminate variations upon said measurements  
9 of said tank bottom pressure caused solely  
10 from atmospheric pressure variations to yield  
11 an atmospheric pressure adjusted tank bottom  
12 pressure;  
13 ambient temperature measurement means for  
14 measuring ambient temperature near said  
15 storage tank;  
16 tank dynamic and barometric pressure adjusted tank  
17 bottom pressure calculation means configured  
18 for receiving third data indicative of said  
19 atmospheric pressure adjusted tank bottom  
20 pressure, for receiving fourth data  
21 indicative of ambient temperature  
22 measurements by said ambient temperature  
23 measurement means, for receiving fifth data

1                   indicative of expansion characteristics of  
2                   said storage tank, and for adjusting said  
3                   third data with reference to said fourth and  
4                   fifth data to substantially eliminate  
5                   variations upon measurements and calculations  
6                   of said barometric pressure adjusted tank  
7                   bottom pressure, caused solely by dimensional  
8                   changes in said storage tank resulting from  
9                   atmospheric temperature variations, to yield  
10                  a tank dynamic adjusted tank bottom pressure;  
11                  tank content mass calculation means for  
12                   calculating mass content data representative  
13                   of the contents of said storage tank  
14                   substantially based on said tank dynamic  
15                   adjusted tank bottom pressure and user input  
16                   data reflecting physical characteristics of  
17                   said contents of said storage tank;  
18                  selecting data storage means for collecting a plurality  
19                   of mass content data as generated by said tank  
20                   content mass calculation means over a plurality of  
21                   points in time;  
22                  selecting computing means configured for generating a  
23                   human perceptible indicating of changes in said

1 mass content data between a plurality of said  
2 points in time;  
3 placing said protective enclosure means substantially  
4 at a bottom interior surface of said storage tank;  
5 actuating said mass detection system; and  
6 observing data indicative of changes in said mass  
7 content data attributable to leakage of said  
8 storage tank to detect of such leakage.

9  
10 10. The method of Claim 9 further comprising the steps of:  
11 securing all input and outflow orifices of said storage  
12 tank before said actuation of said mass detection  
13 system; and  
14 substantially selectively processing said mass content  
15 data which were generated approximately between  
16 sunset and sunrise at an installation site of said  
17 system.

18  
19 11. The apparatus of Claim 9 wherein said protective  
20 enclosure means is configured for maintaining at least some  
21 components of said apparatus within said canister, including  
22 said differential pressure sensor, but excepting said low

1 pressure measurement component and said high pressure  
2 measurement component, in a substantial vacuum.

3  
4 12. The apparatus of Claim 10 wherein said protective  
5 enclosure means is configured for maintaining at least some  
6 components of said apparatus within said canister, including  
7 said differential pressure sensor, but excepting said low  
8 pressure measurement component and said high pressure  
9 measurement component, in a substantial vacuum.

10  
11 13. The apparatus of Claim 9 further comprising protective  
12 enclosure temperature management means configured for  
13 maintaining the temperature of said protective enclosure  
14 substantially at a user-specified temperature.

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16 14. The apparatus of Claim 11 further comprising protective  
17 enclosure temperature management means configured for  
18 maintaining the temperature of said protective enclosure  
19 substantially at a user-specified temperature.

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21 15. The apparatus of Claim 12 further comprising protective  
22 enclosure temperature management means configured for

1 maintaining the temperature of said protective enclosure  
2 substantially at a user-specified temperature.

3  
4 16. A method for detecting leaks in a storage  
5 receptacle; comprising the steps of:

6 differential pressure sensor means having a low  
7 pressure measurement component and a high  
8 pressure measurement component;

9 protective enclosure means for protecting said  
10 differential pressure sensor means from  
11 materials and conditions when immersed in  
12 liquid contents of said storage tank;

13 said high pressure measurement component being  
14 configured for measuring tank bottom pressure  
15 within a liquid in which said cannister is  
16 immersed;

17 said low pressure measurement component being  
18 configured for receiving data indicative of  
19 atmospheric pressure substantially at the  
20 surface of said liquid

21 first barometric pressure measuring means  
22 configured for measuring atmospheric pressure  
23 substantially at the surface of said liquid

1           when said protective enclosure means is  
2           immersed therein and for communicating such  
3           measurement to said low side measurement  
4           component of said differential pressure  
5           sensor;

6           second barometric pressure measuring means  
7           configured for measuring atmospheric pressure  
8           substantially at the surface of said liquid  
9           when said protective enclosure means is  
10          immersed therein;

11          barometric pressure and differential pressure  
12          calculation means configured for receiving  
13          first and second data reflecting,  
14          respectively, said tank bottom pressure and  
15          of said barometric pressure as measured by  
16          said first barometric pressure measuring  
17          means and for calculating pressure  
18          attributable to liquid content of said  
19          storage tank, and receiving third data from  
20          said second barometric measuring means and,  
21          based thereon, adjusting said pressure  
22          attributable to said contents of said storage  
23          tank to substantially eliminate variations

1                   upon said measurements thereof caused solely  
2                   from atmospheric pressure variations to yield  
3                   an atmospheric pressure adjusted tank bottom  
4                   pressure;

5           ambient temperature measurement means for  
6           measuring ambient temperature near said  
7           storage tank;

8           tank dynamic and barometric pressure adjusted tank  
9           bottom pressure calculation means configured  
10          for receiving fourth data indicative of said  
11          atmospheric pressure adjusted tank bottom  
12          pressure, for receiving fifth data indicative  
13          of ambient temperature measurements by said  
14          ambient temperature measurement means, for  
15          receiving sixth data indicative of expansion  
16          characteristics of said storage tank, and for  
17          adjusting said fourth data with reference to  
18          said fifth and sixth data to substantially  
19          eliminate variations upon measurements and  
20          calculations of said barometric pressure  
21          adjusted tank bottom pressure, caused solely  
22          by dimensional changes in said storage tank  
23          resulting from atmospheric temperature



1 variations, to yield a tank dynamic adjusted  
2 tank bottom pressure;  
3 tank content mass calculation means for  
4 calculating mass contents of said storage  
5 tank substantially based on said tank dynamic  
6 adjusted tank bottom pressure and user input  
7 data reflecting physical characteristics of  
8 said contents of said storage tank;  
9 selecting data storage means for collecting a plurality  
10 of mass content data as generated by said tank  
11 content mass calculation means over a plurality of  
12 points in time;  
13 selecting computing means configured for generating a  
14 human perceptible indicating of changes in said  
15 mass content data between a plurality of said  
16 points in time;  
17 placing said protective enclosure means substantially  
18 at a bottom interior surface of said storage tank;  
19 actuating said mass detection system; and  
20 observing data indicative of changes in said mass  
21 content data attributable to leakage of said  
22 storage tank to detect of such leakage.  
23

1 17. The method of Claim 16 further comprising the steps of:  
2 securing all input and outflow orifices of said storage  
3 tank before said actuation of said mass detection  
4 system; and  
5 substantially selectively processing said mass content  
6 data which were generated approximately between  
7 sunset and sunrise at an installation site of said  
8 system.

9  
10 18. The apparatus of Claim 16 wherein said protective  
11 enclosure means is configured for maintaining at least some  
12 components of said apparatus within said canister, including  
13 said differential pressure sensor, but excepting said low  
14 pressure measurement component and said high pressure  
15 measurement component, in a substantial vacuum.

16  
17 19. The apparatus of Claim 17 wherein said protective  
18 enclosure means is configured for maintaining at least some  
19 components of said apparatus within said canister, including  
20 said differential pressure sensor, but excepting said low  
21 pressure measurement component and said high pressure  
22 measurement component, in a substantial vacuum.  
23

1 20. The apparatus of Claim 16 further comprising protective  
2 enclosure temperature management means configured for  
3 maintaining the temperature of said protective enclosure  
4 substantially at a user-specified temperature.

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6 21. The apparatus of Claim 17 further comprising protective  
7 enclosure temperature management means configured for  
8 maintaining the temperature of said protective enclosure  
9 substantially at a user-specified temperature.

10  
11 22. The apparatus of Claim 18 further comprising protective  
12 enclosure temperature management means configured for  
13 maintaining the temperature of said protective enclosure  
14 substantially at a user-specified temperature.